10/543105

JC14 Rec'd PCT/PTO 22 JUL 2005

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of

Jens RICHTER

Corres. to PCT/EP2003/012496

For: HEAT EXCHANGER, PARTICULARLY EXHAUST GAS COOLER FOR MOTOR VEHICLES

VERIFICATION OF TRANSLATION

Commissioner for Patents
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Sir:

I, Susan ANTHONY BA, ACIS,

Director of RWS Group Ltd, of Europa House, Marsham Way, Gerrards Cross, Buckinghamshire, England declare:

that the translator responsible for the English translation of the attached is familiar with both the German and the English language, and that, to the best of RWS Group Ltd knowledge and belief, the English translation of International Application No. PCT/EP2003/012496, and that the English translation is a true, faithful and exact translation of the corresponding German language paper.

I further declare that all the statements made in this declaration of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful, false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful, false statements may jeopardize the validity of legal decisions of any nature based on them.

Date: July 7, 2005

Signature :

For and on behalf of RWS Group Ltd

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Heat exchanger, in particular exhaust gas cooler for motor vehicles

The invention relates to a heat exchanger, in particular a charge air cooler or exhaust gas cooler for motor vehicles according to the preamble of Patent Claim 1, disclosed by DE-A 199 07 163 by the applicant.

DE-A-199 97 163 by the applicant has disclosed a welded exhaust gas heat exchanger with a bundle of rectangular tubes through which exhaust gas flows on the inside and around which coolant flows on the outside. The bundle of tubes is connected via tube bottoms to a housing which has coolant connections. The exhaust gas enters the bundle of tubes via an inlet diffuser and leaves the heat exchanger via an outlet diffuser. This design is relatively complex, in particular owing to the welding technology (laser welding) which is applied.

A similar tube bundle heat exchanger, but one with a soldered round tube design, was disclosed by WO 00/26514. However, such tube bundle systems have potential in terms of their power density, in particular compared to plate systems.

DE-A 198 33 338 and DE-A 198 46 518 have disclosed exhaust gas heat exchangers with a plate design in which flow ducts for the exhaust gas and the coolant are formed from identical or different types of heat exchanger plates. These known exhaust gas heat exchangers are distinguished by a large number of individual parts and have the disadvantage that the heat exchanger plates have in some cases complicated plate shapes which entail high tool costs.

Finally, DE-A 195 11 991 by the applicant has disclosed a plate heat exchanger with a stack design, the flow

ducts of which have different flow duct heights owing to the different heat exchange media. This known heat exchanger with stack plates is determined in particular for cooling charge air or exhaust gas by means of the coolant of the internal combustion engine. However, this heat exchanger has an increased pressure loss owing to the 90 degree deflections of gas and coolant.

The object of the present invention is to improve a heat exchanger of the type mentioned at the beginning to the effect that it can be manufactured as easily as possible and with low costs, in particular with a reduced number of parts.

The means of achieving this object are obtained from the features of patent claim 1. According to the invention, the flow ducts are formed both for the gas, in particular the exhaust gas of an internal combustion engine or the charge air for the internal combustion engine and for the coolant by means of a metal strip which is formed in a meandering shape, corrugated shape or trapezoidal shape, and by the housing. The housing and metal strip form a soldered block with flow ducts which are separated from one another. An advantage here is the simple design since special plates do not need to be manufactured, stacked and soldered to one another for each flow duct, whether for the gas or for the coolant. It is also advantageous that the cross section of the flow ducts can be configured in a variable way, for example in a rectangular shape, trapezoidal shape, corrugated shape or the like. The gas ducts and coolant ducts lie directly one next to the other so that an efficient exchange of heat between the two media can take place. The number of individual parts for the heat exchanger according to the invention is considerably reduced.

According to one advantageous development of the invention, the coolant ducts are closed off at the ends

by a tube bottom which is embodied in the form of a comb. The tube bottom has individual prongs or dividing webs which are inserted into the open sides of the meandering section and subsequently soldered. The coolant side is thus sealed with respect to the gas side. This simplifies the mounting and reduces the manufacturing costs since it is not necessary to insert any tube ends of a bundle of tubes into a tube bottom and weld or solder it in.

According to a further advantageous embodiment of the invention, the flow ducts are embodied in an approximately rectangular shape, with a preferably larger cross section being selected for the gas ducts. The rectangular cross-sectional shape of the flow ducts result in a compact, compression-proof and largely vibration-free heat exchanger block. The soldering of the comb-like tube bottom to the meandering section, i.e. the end-side closing off the coolant duct, is also carried out in a particularly simple and reliable way owing to the rectangular section. The rectangular flow ducts are suitable in particular for accommodating turbulence inserts (see below).

According to a further embodiment of the invention, the housing is composed of a U-shaped section and a terminating plate or of two U-shaped sections which enclose the meandering section. This permits simple mounting and simple soldering.

According to a further advantageous embodiment of the invention, in each case a distributor duct and a collecting duct for the coolant are arranged on the housing or the terminating plate and extend transversely with respect to the coolant ducts. This results in a uniform distribution of the coolant over all the coolant ducts and thus uniform cooling of the exhaust gas. It is also advantageous here if the distributor ducts and/or collecting ducts are formed

directly from the terminating plate or the U-shaped section.

In a further embodiment of the invention, turbulence inserts are arranged in the coolant ducts and/or gas ducts in order to improve the transfer of heat and - owing to the soldering - also the pressure resistance and the vibration resistance of the entire heat exchanger (the turbulence inserts and ribs act as tie rods).

An exemplary embodiment of the invention is illustrated in the drawing and will be described in more detail below. In said drawing:

fig. 1	shows a heat exchanger as an exhaust gas cooler,
fig. 2	shows the heat exchanger in an exploded view,
fig. 2a	shows a folded metal strip with flow ducts,
fig. 3	shows the heat exchanger without a housing,
fig. 4	shows an exhaust gas cooler with modified housing shape, and
fig. 4a	shows the exhaust gas cooler without a diffuser.

Fig. 1 shows an exhaust gas cooler 1 in a simplified illustration with a diffuser 2 for the ingress of the exhaust gas which is indicated by an arrow A. The exhaust gas cooler 1 has an approximately cuboid housing 3 with an upper side 3a where a coolant distributor duct 4 and a coolant collecting duct 5, on which there are coolant connections 4a, 5a, are arranged. The coolant for cooling the exhaust gas thus enters the exhaust gas cooler 1 via the coolant connection 4a, and leaves said exhaust gas cooler 1 via the coolant connection 5a, the coolant being indicated

by arrows K. An outlet diffuser, via which the exhaust gas leaves the exhaust gas cooler 1, is not illustrated here. Such an exhaust gas cooler is applied in particular in motor vehicles with exhaust gas recirculation (EGR).

Fig. 2 shows the heat exchanger according to fig. 1 with its individual parts in an exploded illustration. Identical reference numbers are used for identical parts. The diffuser 2 is shifted counter to the direction of flow of the exhaust gas and the housing 3 with the distributor ducts 4 and collecting ducts 5 for the coolant is lifted upwards. Below it it is possible to see a heat exchanger block 6 which is composed of a metal strip 7 which is folded in a meandering shape. This meandering section 7 forms, on the one hand, flow ducts 8 for the exhaust gas and, on the other hand, flow ducts 9 for the coolant.

The flow ducts 9 for the coolant are open toward the upper side of the block 6, and the flow ducts for the exhaust gas are open toward the lower side of the block 6. Turbulence insets 10, 11 which protrude beyond the block 6 in order to make them clearly visible are inserted into the flow ducts 8, 9, which each have a rectangular cross section. Above the block 6 it is possible to see two tube bottoms 12, 13 which are embodied in the form of a comb and have individual prongs 14, 15 or dividing webs. The latter are inserted from top to bottom (in the drawing) into the flow ducts 9, i.e. the coolant ducts, which are open toward the top, with the result that said prongs 14, 15 or dividing webs close off the cross section of said ducts completely at the ends. After the tube bottoms 12, 13 have been inserted into the coolant ducts 9, the housing 3 is pushed over the heat exchanger block 6 so that the distributor ducts 4 and collecting ducts 5 extend transversely over the coolant ducts. The area of the coolant duct 9 which is located between the coolant

ducts 4, 5 is covered by the upper side 3a of the housing and closed off. The lower side (not visible in the drawing) of the heat exchanger block 6 is closed off by a terminating plate (not illustrated) which thus closes off the exhaust gas ducts 8 towards the bottom. Of course it is also possible to position the terminating plate on the upper side 3a and to embody the housing 3 as an upwardly open box with a U-shaped section which would be composed of a lower side 3b and two side faces 3c, 3d.

Fig. 2a shows the metal strip 7 as individual part which is folded into a meandering shape. The respective angled folding or edge bending of the metal strip forms rectangular flow cross sections for the flow ducts 8, 9 which each have the same length l. However, the width is different: the exhaust gas ducts 8 have a width b1 which is greater than the width b2 of the coolant ducts 9.

Fig. 3 shows the exhaust gas cooler 1 according to figs. 1 and 2 but without a housing 3 and without a diffuser 2, i.e. the heat exchanger block 6. Here too, identical reference numbers are used for identical parts. One views in the direction A of flow of the exhaust gas (fig. 1) onto the end side of the exhaust gas ducts 8 which are separated from one another by the dividing webs or prongs 14 of the comb-like tube bottom 12. The dividing webs 14 simultaneously close off the coolant ducts 9 at the ends. In the gas ducts 8 there are turbulence inserts 10. The flow of the coolant in the exemplary embodiment illustrated is in the same direction as the exhaust gas, i.e. the coolant firstly enters the distributor duct 4 and is distributed there transversely over the coolant ducts 9, then flows through the coolant ducts 9 in the direction of the exhaust gas stream and then reaches the collecting duct 5 from where the coolant leaves the exhaust gas cooler

1 again. A counter flow with a reverse direction of flow of the coolant is also possible.

The exhaust gas cooler 1 which is described above is preferably manufactured from stainless steel. However, the heat exchanger 1 can also be applied as a charge air cooler for cooling the combustion air of internal combustion engines - it is then preferably manufactured from an aluminum alloy.

Fig. 4 shows a further exemplary embodiment of an exhaust gas cooler 16 with a modified housing shape which is composed of two U-shaped sections 17, 18. Both U-shaped sections 17, 18 are connected laterally with longitudinal seams, the front longitudinal seam 19 of which is visible. At the ends, the exhaust gas cooler 16 has an exhaust gas inlet connector, i.e. a diffuser 20. The upper U-shaped section 17 has a distributor duct 21 which runs transversely and has a coolant inlet connector 22 as well as a collecting duct 23 which also runs transversely and has a coolant outlet connector 24. Both ducts 21, 23 may be formed out of the sheet metal of the U-shaped section 17.

Fig. 4a shows the exhaust gas cooler 16 without the diffuser 20, i.e. with an end face 25 for the ingress of exhaust gas which is indicated by an arrow A. The end face 25 has, analogously to the previous exemplary embodiment, exhaust gas ducts 27 which, viewed in the drawing, are open toward the bottom. The coolant ducts 26 which are closed off at the ends are open toward the top and are thus connected to the distributor duct 21. The coolant is thus firstly distributed laterally over all the coolant ducts 26 and then flows through the exhaust gas cooler 16 in the longitudinal direction until it emerges again via the collecting duct 23. The two housing halves 17, 18 can be seen here clearly as U-shaped sections.